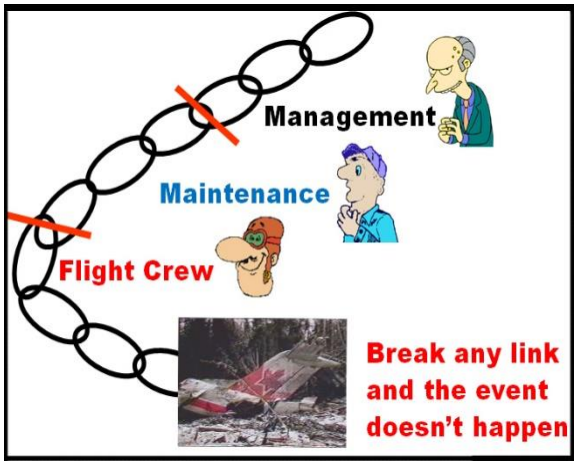
The Perfect Storm seems like an oxymoron as what can be perfect about a storm? Where did this saying come from and just what does it mean today? A Perfect Storm is the title of a book written in 1997 by Sebastian Junger that told the true story of a fishing boat that encountered a severe storm in the Atlantic It is said that a meteorologist coined the phrase "the perfect storm" as he saw beauty in the power of three weather systems colliding to create the storm of the century in the North Atlantic in Oct 1991. To know if the boat survived you'll have to read the book. Today, the perfect storm has come to mean: a rare combination of events or circumstances creating an unusually bad situation or when the seemingly impossible occurs.

What I would like to relate "the perfect storm" to is what we in accident investigation call: "the chain of events"(CofE). Accidents are usually "a rare combination of events or circumstances" and definitely "create unusually bad situations". I also would often hear something along the lines of "I never would have believed that this could possibly happen" after the accident.

So just what is a CofE and what can we do about it? The chain of events could also be called an "error chain" as it is highly likely that errors will be part of any chain leading to an aviation accident.



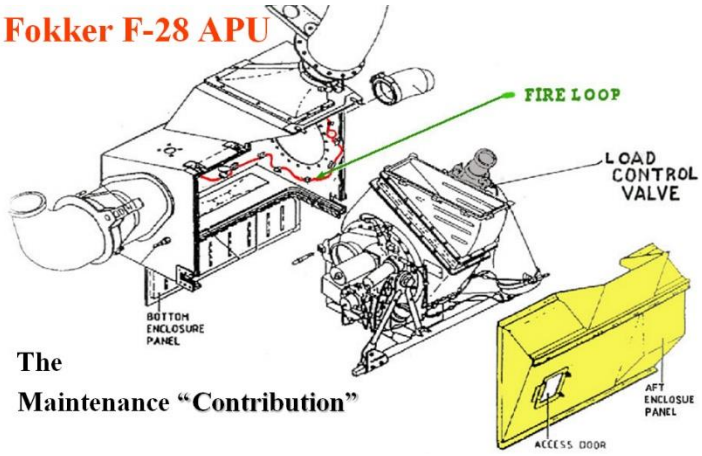
In my opinion a CofE is a group of contributing factors, some of which could have been around for years that come together like links in a chain to form a chain that leads to or ends in an accident. These links must come together at a specific time to create "the perfect storm". Break any one link in the chain and the accident likely doesn't happen. Sometimes a timing of seconds will break and therefore stop the chain. For example: An AME/AMT is just about to tighten a fuel line when he is asked for his help by an apprentice. The fuel line doesn't get tightened and seven people die at the end of the error chain. (See the storyline of Case Study #6– "The Price of a Mistake") on our website www.system-safety.com.) If the call for assistance had been made mere seconds earlier the fuel line would have still been off while seconds later and it would have been tightened.

Let's look at the accident that resulted in my leaving the Transportation Safety Board of Canada to join Transport Canada to develop human factors training for AMEs As we will see, maintenance had at least three links that could have broken the CofE and prevented the accident. While they certainly didn't cause the accident, they contributed three links to the CofE giving them three opportunities to break the chain and prevent the accident. Our job as

maintenance is to break links in the CofE and we do it all of the time. For example, during a routine inspection you find a frayed elevator cable. You have just broken a link of a fatal accident I investigated, where the AME didn't see the frayed cable and 20 people died when the float equipped Twin Otter nosedived into the water shortly after takeoff.

The last link in a rather long CofE saw the pilots trying to take off from a small Northern airstrip with wet snow on its wings. The aircraft stalled and 24 people died in the ensuing crash. In the so called "good ole days" this would have been labeled simply "Pilot Error" and the end of the story. But, today, we dig ever farther up the CofE looking for the root cause(s).

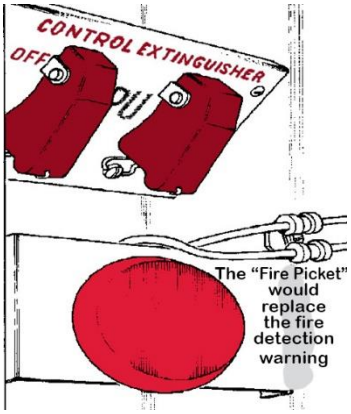
Let's start with the pilot who would be the last person who could break a link and prevent the accident had he decided to not takeoff with the snow on his wings. He knew that he was required to shut down the engines to deice. There was no air-start at this airport and the APU had a big red unserviceable tag on it. Thus, if he shut down to deice there was no means to restart the air start engines. He had 65 passengers and 4 crew in a town with one 35 bed hotel. Also there would be the pressure to complete the flight that was full of passengers anxious to make connections for a long weekend. To top it off, this was the final leg for the crew before time off. To deice meant they would be stuck there with insufficient accommodation for at least a day. He had accumulated 24,100 flying hours with a lot of winter flying experience, but most of it was with turboprop aircraft in which he had taken off in worse situations than this. The F-28 swept wing is super critical to any contamination. With only 87 hours of simulator and flight time on the F-28 he was facing snow with it for the first time. A perfect storm of contributing factors set him up to make the fatal decision. He did not know that he could have legally used the APU to restart the engines and the accident would not have happened.



The Maintenance "Contribution"

Maintenance had put that tag on the APU so let's look at their links. The company bought two 17 year old Fokker F28s, their first jets in their fleet. These aircraft had sat in the desert for the previous two years. None of the maintenance had ever worked on F28s and none had ever worked on APUs of any kind. They received a two week classroom course on the aircraft, three hours of which was on the APU. The aircraft, as one might expect, had numerous snags many of which were being deferred. Part of the problem was they had no spare parts to work with but depended on an agreement with a Chicago airline to provide them parts if they didn't require them. The APU had been written up for the fifth time as having an intermittent low bleed air problem when used for engine start up. Thus, a day before the fatal flight, maintenance obtained and installed a load control valve (LCU) hoping to solve the problem. A test engine start showed that the problem was still there. They then reinstalled the old LCV and on the test engine run everything was back to normal and ground checked serviceable. They then sent a learner out to reinstall the aft enclosure panel (coloured yellow in

the illustration) and close up the APU. The learner had never had any training on the aircraft and failed to notice that when changing the LCV maintenance had moved the fire detection loop. (Storm 1) The learner then pinched the loop while installing the panel. (Storm 2) When maintenance went to start the APU to start the engines in order to taxi the aircraft to the ramp, the fire detection loop wouldn't test. (Storm 3) Maintenance went to the aircraft MEL



(Minimum Equipment List), but found nothing re the detection loop so they chose MEL 90-03 Fire Extinguishing System U/S. (Storm 4) The aircraft flight manual allowed the APU to be used with a U/S fire detection loop as long as it was on the ground and a "fire picket" watched the APU and acted as an APU fire detector. There were guarded switches in the wheel well that could turn off the APU, and if necessary, activate the fire bottle. If the extinguisher system was U/S the APU had to be tagged as unserviceable, as there would be no means to extinguish an APU fire. Maintenance told the departing pilot, but the fatal pilot the next day had no idea that the APU was actually functional under flight manual instructions. The maintenance perfect storm was now ready to enable the pilot's storm to continue to the conclusion. I had the opportunity to interview (I'd prefer to say converse) with the AME who signed the aircraft out as airworthy for its last time. He was a quiet person who was easy to like, but had that haunted pre PTSD look. He was quick to say that "it seemed like the right thing to do" at the time. He would repeat that over and over as every lawyer of every next of kin, survivor or interested party asked him over and over during his three days of inquiry testimony. "Why did you enter an illegal entry into the logbook?" I suspect the answer to that question still haunts him to this day.

From the Commission of Inquiry's report (three volumes containing 1825 pages) came almost two hundred recommendations. Most of these were aimed at the regulatory body and company who had numerous links in the CofE. In fact in the majority of cases the links start with the regulatory body. One such recommendation called for the extension of CRM to include air traffic controllers, dispatchers and maintenance. Today in Canada, it is mandatory that any person who certifies an aeronautical product must have human factors training. Would human factors training have broken the chain of events at the maintenance level? We'll never know for sure but I would like to think that it would have.